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CEMENT AND LIME MANUFACTURE

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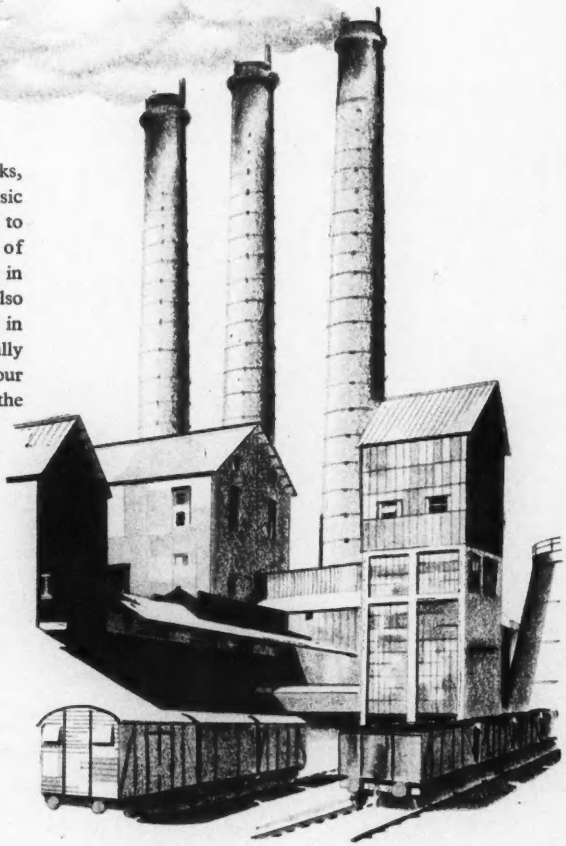

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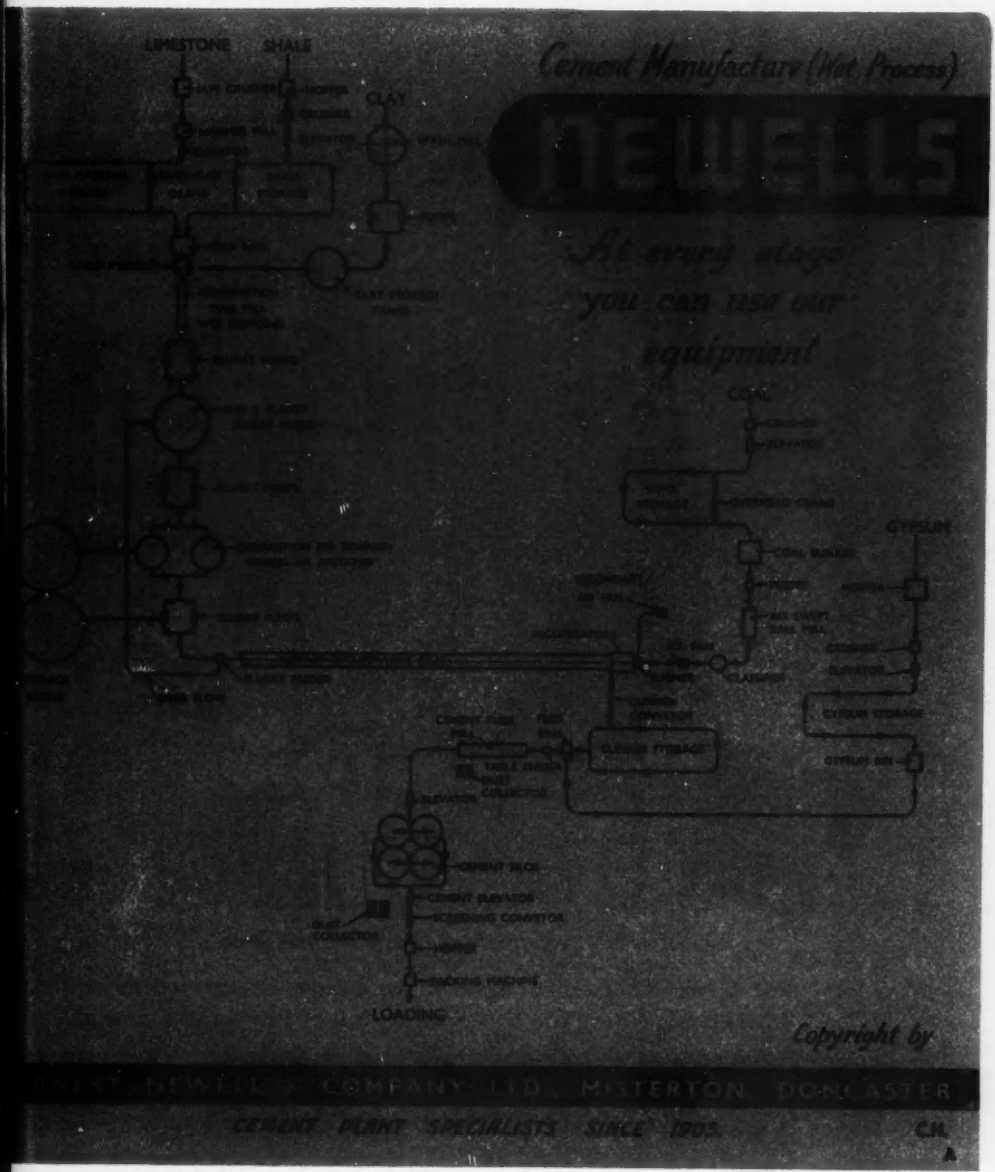
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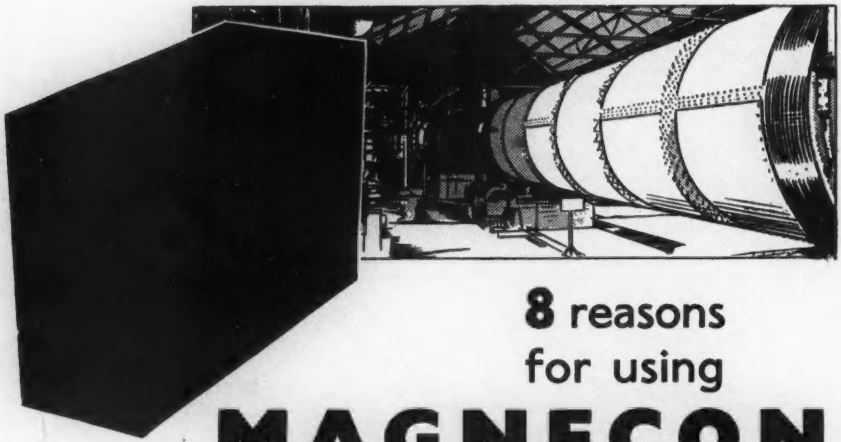

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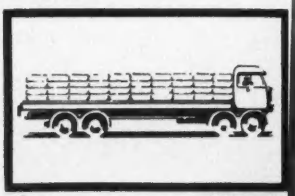

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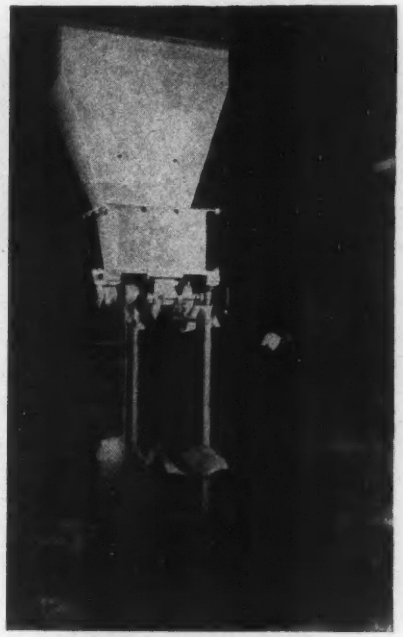

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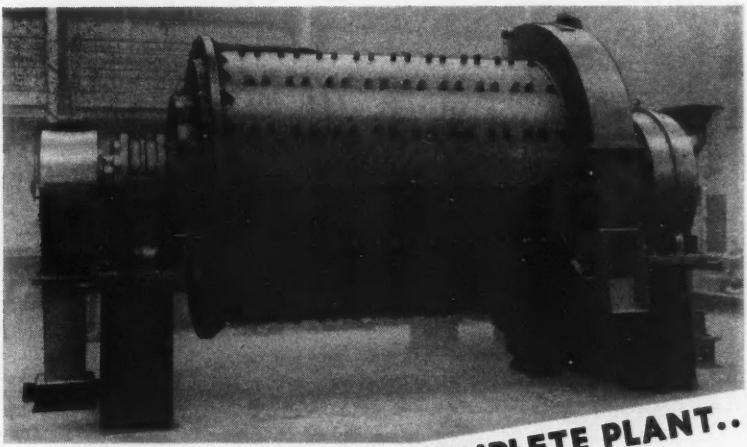

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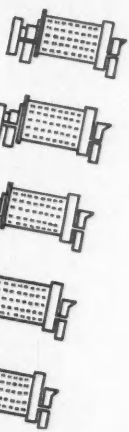

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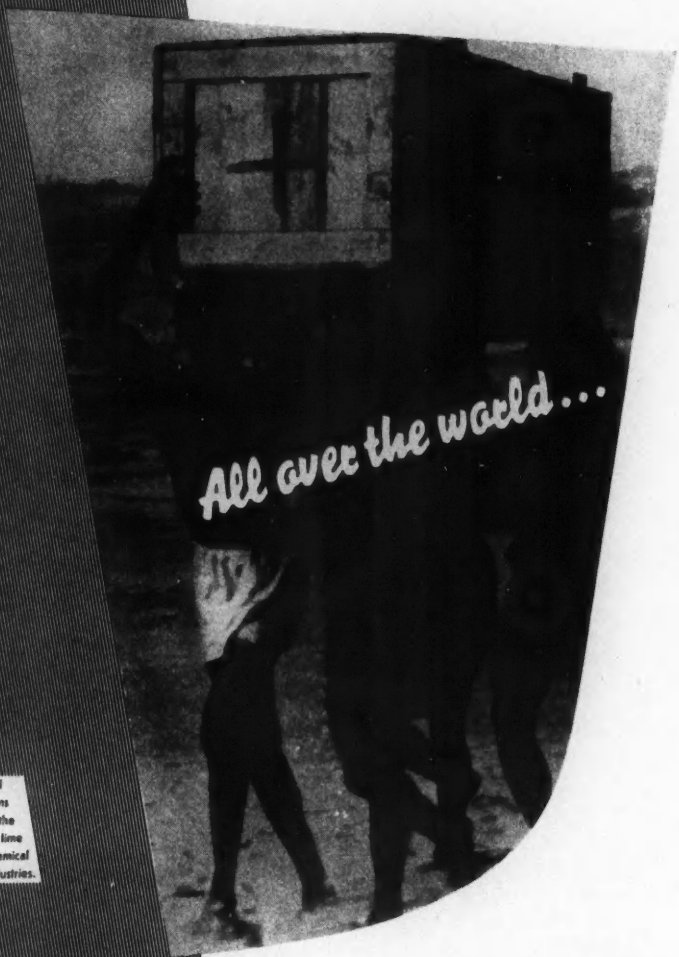

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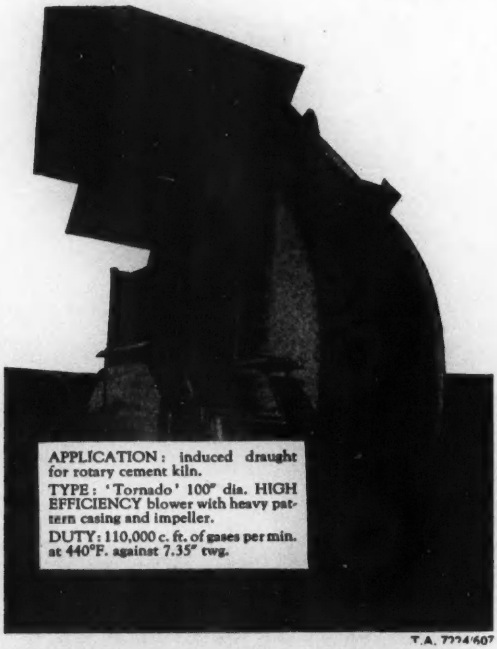

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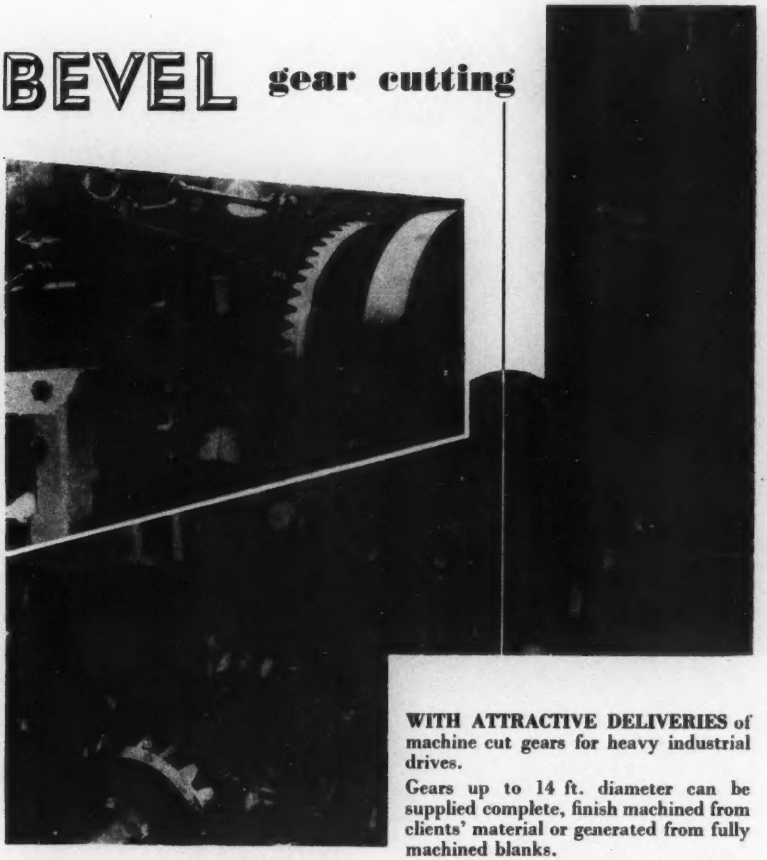

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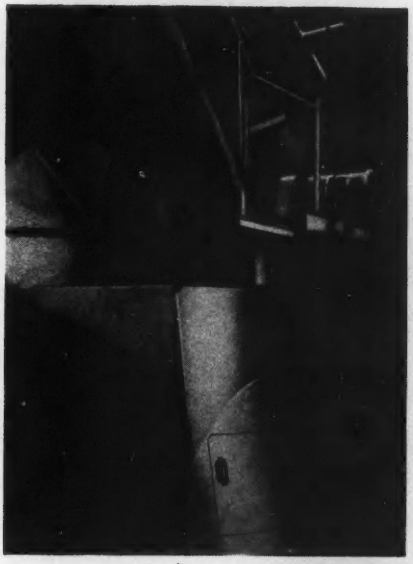

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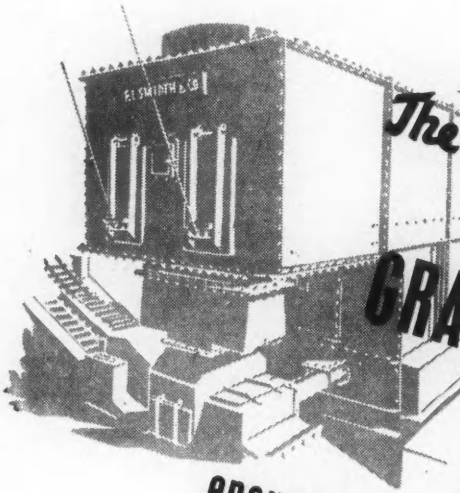

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VOLUME XXVIII. NUMBER 6. NOVEMBER, 1955

Reducing the Loss of Dust.

METHODS used in the reconstruction of two rotary kilns 2·8 m. and 2·3 m. diameter by 61·5 m. long (9 ft. 2 in. and 7 ft. 6 in. by 202 ft.) of an old design at a Russian cement works are described by S. A. Grazhdanski in "Tsement" 1954, 20 (2). The length of the burning zone was increased from 8 m. to 16 m. (26 ft. 6 in. to 53 ft.) and riveted shells were replaced by welded shells. The diameter of the kilns was unchanged. The kilns were lengthened to 75·5 m. (248 ft. 3 in.) by the addition of welded units 16 m. (53 ft.) long and 3 m. (9 ft. 10 in.) diameter at the back-end of each kiln. The length of the dust chamber was reduced from 21 m. (69 ft.) to 7 m. (22 ft. 8 in.) as shown in *Fig.* 1. Each kiln was shut down for 23 days and the whole reconstruction was completed in four months.

Kiln and performance data before and after reconstruction are given in *Table* 1. The slightly lower hourly output of kiln No. 1 compared with kiln No. 2 was due to insufficient fan power. Tests on the reconstructed kiln No. 2 showed an increase in output of 46 per cent. There was, however, a greater loss of dust. In the study of the dust problem on kiln No. 1 prior to its reconstruction, samples

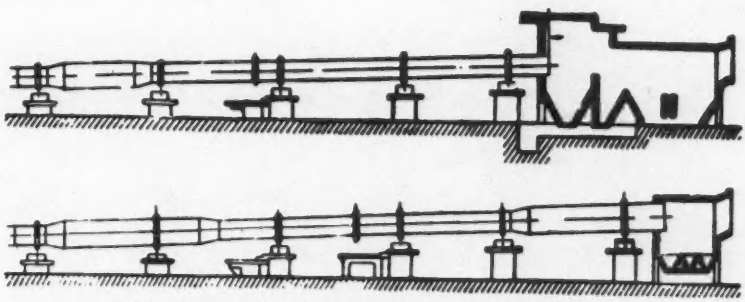
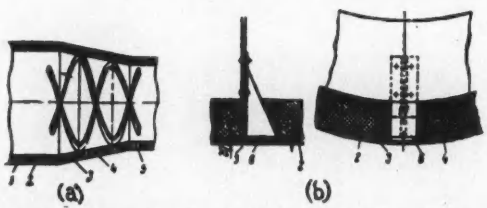


Fig. 1.—Kiln No. 1 Before and After Reconstruction.

Fig. 2.—Method of Fixing the Chain in the Conical Part of the Kiln.

were taken during the passage of the material along the kiln. It was noticed in these tests that if the material left the chain-zone in a dry and ground state it remained in that form throughout most of its passage towards the burning zone. The loss of dust was then high. If, however, the material left the chains in the form of granules, 70 to 80 per cent. of it reached the burning zone in that state and consequently there was a sharp decrease in the loss of dust. Thus the more efficient the granular formation in the initial drying zone the higher is the percentage of the granules reaching the burning zone and the less the loss of dust. It is in this direction that a solution to the problem of reducing the loss of dust was sought.

Prior to the reconstruction of kiln No. 2 the chain zone was 2.3 m. (7 ft. 6 in.) diameter with chains hanging in festoons. The length of the chain curtain was 9·3 m. (30 ft.). In order to study the effect of the chains on the granulation of the material, tests were made with chain zones of varying lengths and type. A chain curtain 12 m. (39 ft. 8 in.) long was tested first. This was unsatisfactory as the material accumulated in the chains, forming a steep cone, its passage was slowed and excessive grinding by the chains took place with no granular formation. The loss of dust was high and the dust-chamber continually overflowed. As the pulverisation of the material was mainly due to the grinding action of the chains, the length of the chain zone was reduced to 9 m. (29 ft. 4 in.) and the tests repeated. Some improvement was noted but the loss of dust was still high. It was thought that better results would be obtained if the passage of the material through the wider part of the kiln could be hastened. A cast-iron helix was fitted for that purpose, as shown in *Fig.* 2. The helix resulted in a considerable improvement in the formation of granules and the loss of dust was much reduced. As, however, the rate of the kiln-feed was increased the loss of dust increased again. The helix was not able to deal efficiently with the additional material. For this



(a) Rotary Kiln. (b) Method of fixing the chain in the conical part of the kiln. (1) Kiln shell; (2) brick lining; (3) transition cone; (4) chain; (5) shell of narrow part of the kiln; (6) bracket.

Fig. 3.—Method of Fixing the Unloading Chains in the Transition Cone of the Kiln.

TABLE 1

	Kiln No. 1		Kiln No. 2	
	Before reconstruction	After reconstruction	Before reconstruction	After reconstruction
Kiln length (ft.)	172·8	212·2	172·8	212·2
Length of burning zone (ft.)	22·5	45	22·5	45
Dia. of drying zone (ft.)..	6·5	8·4	6·5	8·4
Length of dust chamber (ft.)	42	19·7	42	19·7
Pressure in dust chamber (mm. water gauge) ..	15	20	13	30
Diameter to length ratio of kiln	29	35·3	29	35·3
Heat exchange area (sq. ft.)	4928	6328	4928	6328
Exit-gas temperatures (deg. C.)	260	275	260	295
Standard coal consumption (kcal./kg.) ..	2000	1960	2000	1960
Kiln output (tons per hour)	6·4	8·4	6·2	9·1
Percentage increase in output	—	30	—	46

reason the helix was dismantled for the next test, the chain was shortened by a further 3·6 m. (12 ft.) and this length of the curtain was transferred to the feed-end of the zone. The tightness of the curtain was also increased. In this way a " moist " curtain was provided which reduced the loss of dust due to a more liberal coating of slurry on the chains. In addition the thickness of the brick lining was also reduced in order to reduce the steepness of the cone formed by the material and to check its accumulation. Samples taken at various stages of the passage of the material proved that most of the material left the chain zone in the form of granules.

The output rose to 8·8 tons per hour but the loss of dust was still considerable. During a routine stoppage of the kiln two unloading helices were fitted into the kiln transition cone as shown in *Fig.* 3. The length of the curtain was increased to 8·4 m. (27 ft. 3 in.). The helices were fixed to brackets welded to the shell of the kiln. The helical blades were 20 mm. (0·8 in.) thick by 30 mm. (1·2 in.) high and arranged at an angle of 15 deg. to the vertical plane. This proved to be successful. Single granules up to 20 mm. (0·8 in.) diameter appeared, and in general the granular residue on a sieve of 300 apertures per square centimetre was

more than 90 per cent. The moisture content of the granules was from 12 to 17 per cent. The success of the method was proved in subsequent operations of the kiln, when the output of clinker increased to 9 tons per hour or slightly more and the loss of dust was reduced by about 8 per cent.

Methods of Testing Cement and Concrete.

The following notes are taken from the Report of the Road Research Board for the Year 1954 (H.M. Stationery Office. Price 4s.).

COMPRESSIVE TEST FOR CEMENT.—A test for the strength of cement which was suggested by the Associated Portland Cement Manufacturers, Ltd., for inclusion in the British Standards is a crushing test on concrete cubes containing fixed quantities of cement and water. The Board co-operated with 21 other laboratories in comparative tests using (a) aggregate from one source and (b) an aggregate chosen by each laboratory independently. It was found that using the first, or "standard," aggregate the reproducibility between laboratories was about as good as that obtained with the existing vibrated-mortar cube test. With the different local aggregates the reproducibility was not as good, although the aggregate was required to comply with a restrictive specification. The British Standards Institution has, however, accepted in principle the test using local aggregates, since the difficulties which would be involved in calling for a standard aggregate were considered to be too great in relation to the somewhat better reproducibility that would be obtained. The test is likely to replace the existing tensile briquette test which is liable to show wide variations.

ACCURACY OF TESTING MACHINES.—Cases have arisen of differences between the results of compression tests carried out in different machines on groups of nominally similar concrete cubes. A study showed that discrepancies amounting to 10 per cent. or so between certain machines employing elastic-steel weighing rings and those with hydraulic measurement of the load were due in part to misalignment of the weighing rings.

The effect of friction in the spherical seatings of the platens of the testing machines has also been examined. In some machines the surfaces made contact only over a small annular area so that the film of lubricant was pierced and metal-to-metal contact was established under high loads. Reworking the surfaces of the spherical seating in one of the machines and using a special grease reduced the coefficient of friction in the seating from 0·6 to 0·04 and enabled it to move under load.

Alkalis in Portland Cement.

POTASSIUM SALTS AS BY-PRODUCTS.

THE presence of sodium and potassium in Portland cement is generally regarded as undesirable because it is generally considered that they tend to increase the wear of the lining of rotary kilns, affect the setting and hardening of cement, and are responsible for some of the reactions in concrete which cause efflorescence affect paints, and may even destroy the concrete if akali-sensitive additives are used in its manufacture. In view of the possibility of producing potassium and sodium salts as by-products of cement manufacture, this problem is discussed in " Cement—Wapno—Gips " (1955, No. 1), by C. Haranczyk, who writes as follows.

Alkalis in Portland cement are derived from the raw materials and the coal ash. In considering the behaviour of alkalis during the burning process, and particularly assessing the suitability of the raw materials for producing potassium salts, one must introduce an alkali coefficient which is defined as the percentage ratio of the potassium to sodium oxides, that is $MP = \frac{K_2O}{Na_2O}$. The application of this coefficient is based on differences in the behaviour of these two compounds in the raw materials as well as in the manufacturing processes. The value of the coefficient indicates the suitability of the material as a special additive for increasing the amount of potassium obtainable and should be between 3 and 4 for the minimum K_2O content of 4 per cent. Raw materials normally used have from 0·1 to 1·5 by weight of alkalis. In limestones the alkali content is usually less than 1 per cent. In the burning process the alkali content of clinker diminishes very rapidly in comparison with that of the cement raw materials. Hence the sodium oxide is usually regarded as mainly responsible for the effect of alkalis on cement. The total content of alkali in clinker is from 0·6 to 0·8 per cent.

The amount of potassium oxide volatilised in the burning process is usually assumed to be 1 per cent by weight of clinker.

A certain amount of alkali is also contained in the fuel. Assuming that the coal consumption is 40 per cent. of the clinker produced, that the ash is 15 per cent. of the coal, and that the alkali content of the ash is 4 per cent., for a clinker production of 1,000 tons a day the alkali content would be $1000 \times 0{\cdot}4 \times 0{\cdot}15 \times 0{\cdot}04 = 2{\cdot}5$ tons. The amount of coal ash absorbed by clinker is estimated to be from 14 to 100 per cent., depending on the type of kiln. If the absorption takes place before the burning zone a large proportion of K_2O is volatilised in the burning zone, and this can be recovered from the gases together with a certain amount of dust. This can be done, however, only by means of electrostatic precipitators as the average size of the particles does not exceed 10 microns. It is also possible to introduce additional alkalis, mainly sodium hydroxide or sulphite lye, in the form of slurry-fluidising agents; the total amount of alkalis normally introduced in this way is, however, small and can generally be ignored. The reintroduction into the kiln of dust from the filters has also been suggested as a method of increasing K_2O content, but this may lead to accelerated wear of the kiln lining.

In general the production of potassium salt as a by-product of cement manufacture is economical only if the raw materials are rich in potassium.

The Effect of Alkalis on the Properties of Cement.

At the high temperatures of the burning zone, acids such as sulphuric and hydrochloric are expelled from their salts and substituted by SiO_2, Al_2O_3, or P_2O_5; this facilitates the formation of silicates and alumino-silicates. There is also a tendency for an increase in the volatility of sodium and potassium which enter into combination with the free sulphuric and hydrofluoric acids to produce volatile salts; whether sodium sulphate is formed is doubtful. The potassium and sodium oxides, eliminated from their compounds by thermal decomposition, combine with acids according to the foregoing reactions and produce volatile salts, or they are volatilised in the form of oxides. Part of the alkali is absorbed by the clinker compounds. The basic difference between sodium and potassium is the comparatively high volatility of the latter.

Investigations by H. Woods on the volatility of alkali and its dependence on the temperature, the burning time, and the amount of volatilising agent, are an important guide to the correct method of burning clinker when large amounts of alkalis are present and lead to a confirmation of the importance of the alkali coefficient. He found that K_2O volatilises rapidly only at temperatures higher than 1100 deg. C.; even prolonged burning at or below this temperature has an insignificant effect on the loss of K_2O. Samples heated at 1350 deg. C. for half an hour had their K_2O content reduced from 1·7 per cent. to 0·2 per cent. and heating at this temperature for 1½ hours reduced the K_2O content to 0·01 per cent. Na_2O heated under similar conditions had, even after prolonged heating, only a very small degree of volatility. Results corresponding to the industrial conditions of burning clinker were obtained after burning for 1 hour at 1250 deg. C. in a laboratory furnace. Additions of CaF_2 to the kiln-feed had no effect on the volatility of K_2O and Na_2O; calcium sulphate ($CaSO_4$) inhibits the volatility of both, however. This inhibiting effect of $CaSO_4$ on the volatility of alkalis is confirmed by spectral analysis: completely to eliminate this effect it is necessary to employ temperatures given by the electric arc.

The best results in lowering the K_2O content of clinker are obtained by additions of from 0·5 per cent. by weight of calcium chloride. To obtain similar results for Na_2O, the addition of 2·63 per cent. of calcium chloride is necessary. Calcium chloride in clinker acts as a fluxing agent, which is a further advantage. The addition of sodium chloride increases the volatility of K_2O, but also increases the Na_2O content.

Another method of reducing alkali in clinker, as proposed by H. M. Larmour, involves subjecting the clinker to a reducing flame as it leaves the kiln and enters the cooler. In this way, by reheating the clinker to a temperature approaching that in the burning zone, and consequently by its slow cooling, it was possible to lower the K_2O content by 18 per cent. and the Na_2O content by 15 per cent. compared with the normally produced clinker (40 per cent. C_3S).

It is sometimes considered that alkalis possess mineralising properties that facilitate clinker burning. It is therefore of interest to see what effect a reduced alkali content in clinker may have on the degree of clinker burning, the formation of the liquid phase, the mineralogical composition of clinker, and the amount of C_3S formed. Considerable analogy was found between the system CaO—2 CaO. SiO_2—$Na_2O.Al_2O_3$ and the system CaO—2 CaO. SiO_2—CaF_2, which explains to a certain extent the behaviour of Na_2O as a mineralising agent. It was reported by W. C. Hanson and R. H. Bogue that substituting K_2O or Na_2O for CaO to the extent of 0·5 to 2 per cent. in a mixture of oxides corresponding to the composition of the kiln feed burnt at 1425 deg. C. resulted initially in lowering the free-lime content, which, however, increased again with 2 per cent. substitution. Later investigations showed that the introduction of Na_2O to the system SiO_2—Al_2O_3—CaO reduces the amount of the combined lime. A similar effect is ascribed to K_2O, which stabilises C_2S by dissolving in it and thus hinders the formation of C_3S. In addition there is often a partial decomposition of C_3S accompanied by liberation of free lime. Calculations show that 0·5 per cent. of K_2O can be responsible for the formation of 20 per cent. of the solid solution of potash in C_2S, and for 6·5 per cent. of the free lime. A well crystallised clinker rich in K_2O will have more free lime in it than a clinker of a similar composition but cooled slowly and containing $CaSO_4$. This is explained by the possible formation of more stable sulphates.

New Cement Works in Switzerland.

A new cement factory is being built at St. Maurice, Switzerland, at a cost of 15,000,000 Fr.

Cement Production in Turkey.

The capacity of the cement works in Turkey was 1,010,000 tons at the end of the year 1954. Seven new factories are at present being constructed and a further six are planned. The annual capacity is expected to be 2,000,000 tons in 1957 and 2,680,000 tons in 1958.

New Cement Works in Afghanistan.

The Techno-Export Company of Czechoslovakia is to build a new cement works at Jebel-uz-Seraj, Afghanistan, at a cost of 1,500,000 dollars. It is reported that the factory will have a capacity of 100 tons per 24 hours. The Afghan Government estimates that the annual requirement of cement in Afghanistan is 60,000 tons.

New Cement Works in Canada.

It is reported that the Swiss-owned St. Lawrence Cement Company is to build a new factory at Clarkson, Ontario, at a cost of 15,000,000 dollars. The factory is expected to produce about 250,000 tons a year and is due to come into operation in 1957. The same company recently built a cement factory near Quebec City.

The Passage of Materials in Rotary Kilns.

A detailed account of an investigation of the passage of materials along rotary kilns in given by Mr. Johs Rutle, of A/S Christiania Portland Cementfabrik, Oslo, Norway, in " Pit and Quarry " for July 1955. The research was undertaken in collaboration with the Joint Establishment for Nuclear Energy Research at Kjeller, Norway, where it was found possible to prepare radio isotopes by activating in an atomic pile the raw meal used in cement manufacture. Activated raw meal was added to the slurry in quantities of 3·3 grammes every three minutes during a period of two hours. The total activity of the 40 portions added was 30 millicures Na24. Starting three hours after the addition of the first portion of activated raw meal, samples of the clinker were taken at intervals of 12 minutes, and these samples, each of 1½ litres, were weighed and their radioactivity measured. The samples were taken until no activity was present.

In another test a single sample weighing 200 grammes and with a radioactivity of 50 millicures Na24 was added at the slurry inlet and its passage along the kiln was noted by measuring the radiation through the shell of the kiln at points 33 ft apart.

The investigation showed that (1) Materials fed to kiln at the same time passed through the kiln at different speeds; (2) The rate of progress increased gradually when the materials moved from the chain-section and reached a maximum in the calcining zone; thereafter the rate decreased and was a minimum in the burning zone; (3) The progress of the materials varied considerably in different kilns; these variations could not be attributed to differences in the speed or diameter of the kilns. The results also indicated a particularly high dust circulation in one kiln, and that most of the dust was picked up by the gases in the calcining zone.

The wide variations in the rate of progress were in all cases attributed to differences in the size and grading of the nodules; the smaller the nodules, the higher the rate of progress. The extremely high rate in the calcining zone is also attributed to the carbon dioxide expelled in this zone, causing a fluidising of the charge when it penetrates the layer of materials, that is an " airslide " effect. The effect of various factors, such as the draught and the temperature of the burning zone on variations of the loading in the burning zone, can be seen from the results of the investigation.

The investigations led to the conclusion that a uniform grading of the nodules leaving the chain-section is very important. The chain-system should be adjusted to produce nodules with a low dust content because such nodules will as a rule have the most uniform rate of flow and hence the smallest variation in the loading of the burning zone. The nature of the material to be used should be considered when designing the kiln and deciding its slope. This is not possible to-day, but the radio-isotope seems to be an excellent means of extending knowledge.

The author gives his views as follows on the phenomena noted, namely that materials fed to a kiln at the same time pass along the kiln at different speeds, that the speed of flow was different in different kilns, and that the speed of passage varied in different parts of the same kiln.

In the lower part of the chain-section the materials are formed into nodules of various sizes that differ in different kilns. As a rule, the less the water content of the nodules the higher their dust content. Samples taken when the kilns have been stopped have shown that the grading of the nodules passing from the chain-section has a bearing on the grading of the material in the zones between the chain-section and the burning zone. The coarser the grading after the chain-section the coarser the grading in zones between the chains and the burning zone. The grading, however, becomes finer as the materials pass through the de-watering and calcining zones, as the nodules are subjected to abrasion and become more rounded, and the dust content increases successively. The abraded materials fill the voids between the nodules.

The gradually increasing speed of travel from the chain-section towards the burning zone is supposed to be due to the change in the grading of the nodules because of their movement along the kiln. In the calcining zone the carbon dioxide is expelled. This effect, which will be particularly pronounced when the charge contains much dust, is the same as the principle utilised in airslides for the transportation of fine materials, and may be of considerable importance for material passing through the calcining zone. The expelled carbon dioxide reduces the angle of repose and thus increases the speed of travel.

The materials delivered to a kiln at the same time have a wide variation in grading when they pass out of the chain-section. Some materials are formed into big nodules, some into small nodules, and others occur as dust. It has not been established whether these differences in grading are due to the variations in the nature of the materials delivered to the kiln. However, the difference in grading of the materials passing from the chain-section explains the mixing of the materials taking place in the kiln, as the nodules, and particularly the dust, will have a higher speed in the kiln than the big nodules.

Cement Industry in Uganda.

The Uganda Cement Industry is to treble the capacity of the Tororo factory by the end of 1957 making available a production of 150,000 tons per year. This would meet Uganda's normal requirements and provide a surplus for export.

Cement Production in Persia.

The cement factories of the Persian Seven Years' Plan Organisation produced 62,225 tons of cement in the year ended March 1955.

The Cement Industry in Ecuador.

It has been decided to proceed with the construction of a cement factory at Guapan under the management of Industrias Guapan S.A. with a capital of about £580,000.

The Cement Industry in Europe.

A REPORT entitled " The Cement Industry in Europe " has been issued from the office in Paris of the Organisation for European Economic Co-operation. It is published in the English and French languages; the English edition may be obtained from H.M. Stationery Office or through any bookseller at 7*s*.

The report states that cement production in the O.E.E.C. countries of Europe has developed and is continuing to develop very rapidly. The O.E.E.C. countries comprise Austria, Belgium, Denmark, France, Germany, Greece, Iceland, Eire, Italy, Luxemburg, the Netherlands, Norway, Portugal, Sweden, Switzerland, Turkey, and the United Kingdom. During the last three years the expansion has been comparable to that of more recently established and highly progressive industries and has exceeded the average for industry as a whole. In the O.E.E.C. countries output nevertheless increased more slowly from 1951 to 1954 (about 25 per cent.) than from 1948 to 1951 (about 50 per cent.). In 1953 the cement industry of these countries produced over 59 million tons, valued at from $650,000,000 to $700,000,000. In 1954 output rose to over 62 million tons.

Cement production in the O.E.E.C. countries during the last thirty years has developed much more rapidly than others and faster even than the cement industry in the United States. Production amounted to 14,000,000 tons in 1923, 25,000,000 tons in 1930, 36,000,000 tons in 1938 and 50,000,000 tons in 1951. World production rose from 48,000,000 tons to 150,000,000 tons between 1923 and 1951. The index of production for the cement industry rose to 346 in 1951, using 1923 as reference year, whereas the index of production for all manufacturing industries was 228. Cement production in the O.E.E.C. countries between 1923 and 1951 increased by about 36,000,000 tons, whereas production in the United States increased by only about 18,000,000 tons.

Production continued to expand during 1952 and 1953, the total for O.E.E.C. countries rising to 53,500,000 tons in 1952 and 59,000,000 tons in 1953. During the same period, production in the United States rose to 42,600,000 tons in 1952 and 44,000,000 tons in 1953. Output has increased in almost all cement-producing countries, but the expansion was particularly marked in Germany (nearly 30 per cent. more than in 1951), Italy and France. In 1954 production remained at the high level reached in 1953. However, although total output was higher in 1954 (more than 62,000,000 tons), the rate of increase in 1953 was not maintained in 1954. Whereas total production rose by 6 per cent. from 1951 to 1952 and by 10 per cent. from 1952 to 1953, the increase was only 5 per cent. from 1953 to 1954.

At the beginning of 1950 there was surplus capacity, mainly in Germany (3,100,000 tons), Italy (2,000,000 tons), Belgium (1,400,000 tons) and France (800,000 tons). Nevertheless, capacity rose from 50,000,000 tons to 54,000,000 tons during 1950, chiefly as a result of increases in Germany and Italy, where consumption expanded very rapidly during the year. At the same time in some

countries new plant was installed and equipment modernised with the result that capacity was 57,000,000 tons at the end of 1951 and 60,000,000 tons at the end of 1952. Plans for new plant and the modernisation and extension of existing facilities brought the total capacity up to about 64,500,000 tons at the end of 1953. As production rose to 59,000,000 tons in 1953, proportionately better use was made of the capacity than in 1950. Similarly, at the end of 1954 capacity was more than 67,000,000 tons and production about 62,000,000 tons.

In 1950 there were 374 cement works in the O.E.E.C. countries, 147 of which had a capacity of more than 150,000 tons, accounting for 69 per cent. of the total. Three-quarters of these works were equipped with rotary kilns and 25 per cent. with vertical kilns. In 1950, equipment was on an average from ten to twenty years old. In the same year, plans were made for installing new plant and modernising and extending existing plant, and recent information shows that these plans have been carried out and even substantially exceeded in a number of countries.

A new plant with two rotary kilns and a capacity of 420,000 tons was built in Belgium in 1951, and in the same year three works with two rotary kilns and one vertical kiln, with a capacity of 300,000 tons, were built in France. In 1952 another works with one vertical kiln with a capacity of 50,000 tons was built in France. In Italy a works with one rotary kiln and a capacity of 120,000 tons was installed in 1951; in 1952 another works was built with one rotary kiln and a capacity of 80,000 tons; in 1953 four works with a combined capacity of 240,000 tons and with two rotary kilns and two vertical kilns were completed; in 1954 six works with a total capacity of 800,000 tons and with four rotary kilns and two vertical kilns were constructed. In Switzerland a works was built in 1953 with a capacity of 115,000 tons, with one rotary kiln. In the same year, in the United Kingdom a works was built with one vertical kiln with a capacity of 30,000 tons. Between 1952 and 1954 six works with seven rotary kilns were built in Turkey with a total capacity of 752,000 tons, but in the same period some kilns were taken out of commission.

To sum up, countries which have supplied data on this subject have together 25 works equipped with 20 rotary kilns and seven vertical kilns, representing a capacity of nearly 3,000,000 tons, built between 1951 and 1954.

Most of the new equipment consists of rotary kilns, and the principal countries which have carried out such investments are Italy, France, Portugal, United Kingdom, and Belgium. In 1951 eight rotary kilns and one vertical kiln were installed in existing works; in 1952 there were installed 18 rotary kilns and four vertical kilns; in 1953, 20 rotary and five vertical kilns; in 1954, 11 rotary and two vertical kilns. To these should be added ten rotary kilns installed between 1951 and 1954 in Portugal and four in Austria, although, in the latter case, the year in which they were installed is not given.

Modernisation and enlargement schemes were carried out during 1951-1954 as follows: Italy, 15 rotary kilns and two vertical kilns; France, 13 rotary and four vertical kilns; Portugal, ten rotary kilns; the United Kingdom, nine rotary kilns; Belgium, seven rotary kilns; Switzerland, two rotary kilns and six vertical kilns;

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Sweden, 4 rotary kilns; Austria, one rotary and three vertical kilns; Denmark, three rotary kilns; Eire, two rotary kilns; the Netherlands, one rotary kiln. The total for all countries from which information has been received is 67 rotary and 15 vertical kilns. The number of kilns installed in Germany is not yet known. Consequently, between 1951 and 1954, 87 rotary and 22 vertical kilns were installed.

Labour accounts for one-fifth, at most, of total production costs. In 1950, about 80,000 workers were employed in the cement industry in the O.E.E.C. countries and the output (annual average) was 560 tons per productive worker. In the United Kingdom in the year 1951, 11,900 productive workers produced 10,300,000 tons of cement; in 1954, 12,300 productive workers produced 12,840,000 tons of cement.

In the United Kingdom, the proportion of cement delivered loose in 1954 was 20 per cent. In only three other countries was more than 20 per cent. delivered loose, namely Sweden 30 per cent., the Netherlands 22 per cent., and Switzerland 21½ per cent.

Exports of cement rose steadily from 1950 to 1953. In 1952 exports were 7,500,000 tons, and 7,980,000 tons in 1953. These quantities represented about 13·5 per cent. of production in 1953. In 1954, total exports were about 6,500,000 tons and represented only 10·4 per cent. of the output. In 1954 the United Kingdom, Belgium, Germany and France were responsible for 87 per cent. of all cement exports from O.E.E.C. countries.

Forecasts of increased capacity during the next three years are as follows. Italy: seven new works with seven rotary kilns representing an annual capacity of 735,000 tons. United Kingdom: one works with one rotary kiln and a capacity of 175,000 tons. Denmark: one works with one rotary kiln of 125,000 tons capacity. Full information on German projects is not available, apart from one works with two kilns due to be completed in 1955. In addition, Italy has plans for installing in existing works during the next three years eleven rotary kilns and three vertical kilns with a capacity of 1,340,000 tons During the same period Belgium plans to install five rotary kilns to replace existing units, Austria four rotary kilns and two vertical kilns, Sweden three rotary kilns, Switzerland two rotary kilns and two vertical kilns, and France two rotary kilns and one vertical kiln. Denmark will install one rotary kiln in 1955. Turkey has a considerable development programme as a result of which its productive capacity might be doubled by 1957. It is anticipated that the annual capacity of the United Kingdom will be 12,700,000 tons at the end of 1955, 13,000,000 tons at the end of 1956, and 13,250,000 tons at the end of 1957.

The "Self-Desiccation" of Portland Cement Pastes

AN investigation has been made by Mr. L. E. Copeland and Mr. R. H. Bragg, of the American Portland Cement Association, into the rate of hydration of Portland cement pastes hardened in sealed vials compared with moist-cured pastes. The authors state that when freshly placed concrete is cured, some of the initially free water becomes combined chemically with cement constituents, creating a structure whose external dimensions are not appreciably different from those of the mould. Although the volume of the solid phase increases as curing proceeds, the volume of the new solid is less than the combined volumes of the cement and water before chemical combination takes place, and the concrete will absorb water if water is available. Since most of the hydration products are colloidal, the surface area of the solid phases increases enormously during hydration, and a large part of the free water becomes adsorbed on these surfaces. If the system is sealed to prevent ingress of water, the removal of free water by chemical reaction leaves too little water to saturate the solid surfaces, and the relative humidity in the system decreases. This effect has been called "self-desiccation." From a consideration of the internal volume changes of the system (cement plus water) and the fact that cement hydration products (gel) can form only in water-filled space, Mr. T. C. Powers has shown that self-desiccated pastes should experience a reduction in the amount of liquid water in contact with the solid phases. From this he argued that the rate and extent of hydration should be lower than that obtained with pastes that are cured continuously moist. The data were used to show that, in a sealed specimen, hydration would cease when the chemically combined water became equal to about one-half the initial mixing water, and that maximum hydration of cement could not occur with water-cement ratios less than about 0·5.

Data of various investigators obtained from studies of cement hydration at various relative humidities were cited as an indication that useful hydration would cease when the relative humidity of a sealed paste had fallen to about 75 or 80 per cent.

The paper gives the results of simultaneous measurements of relative humidity and extent of hydration of neat cement pastes cured in sealed flasks at room temperature for one year. Initial water-cement ratios of 0·44, 0·53 and 0·59 were chosen as being representative of the water-cement ratios normally used in making concrete. Originally it was intended that the experiments continue until no measurable changes could be detected, but they were concluded at one year when it became apparent that further changes were likely to be small and that equilibrium would not be reached for several years.

The experiment was designed to obtain measurements of total water, chemically combined water, and relative humidity of neat cement pastes at scheduled time intervals. The pastes were cured (*a*) in sealed containers and (*b*) continuously moist in order to determine the effect of self-desiccation on the rate and extent of the hydration of the cement.

A summary of the results of the investigation is as follows:

(1) The relative humidity within sealed pastes decreased as the cement hydrated. (2) At a given age the relative humidity was higher the higher the water-cement ratio. (3) At the lowest water-cement ratio used, namely 0·44, the lowest relative humidity reached was 94 per cent. at one year. (4) With water-cement ratios equal to or greater than 0·53, sealed and moist-cured specimens hydrated at the same rate throughout the test period. (5) With a water-cement ratio of 0·44, the rate of hydration of sealed specimens was below that of moist-cured specimens after the first ten days. Sealed specimens required 45 days to reach the same amount of hydration produced in 28 days by moist curing. The effect of self-desiccation is greater at later ages. (6) The rate of hydration was lower the lower the water-cement ratio after the first ten days; this was true for both methods of curing.

In a previous publication of the laboratory of the American Portland Cement Association it was concluded that to obtain the maximum possible rate of hydration at constant temperature concrete must be kept saturated or nearly so. The experiments reported in this paper show that such a statement is true for water-cement ratios less than about 0·5. For higher water-cement ratios the rate of curing in sealed specimens is the same as that in specimens kept fully saturated. This indicates that, if a curing membrane were perfectly impervious, membrane-curing would be as effective as water-curing for all but the richer grades of concrete.

Details of the tests are given in the Bulletin of the American Society for Testing Materials for February 1955.

New Cement Works in Colombia.

A new cement works is to be built at Cordoba with a capacity of 150 tons a day; the capital of six million pesos is being provided by the owners of the cement works at Antioquia and Atlantico.

The Industrial Development Institute of the Ministry of Development is to build a cement works at Boyaca at a cost of two million pesos. It is reported that Mr. Henry Kaiser, the American industrialist, is interested in this project.

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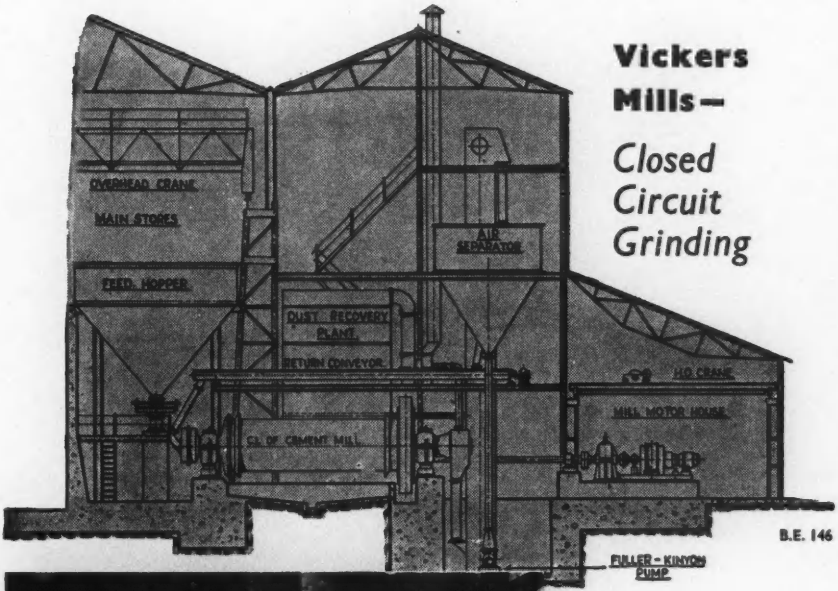

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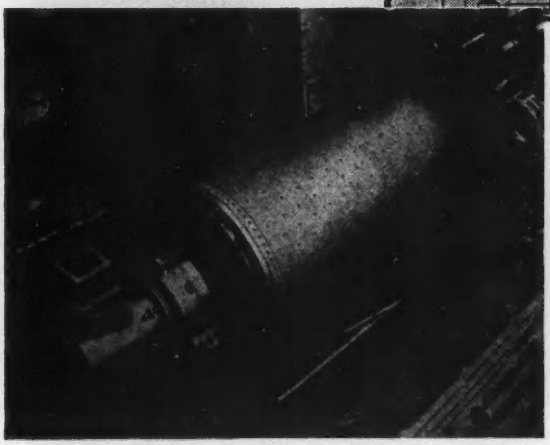

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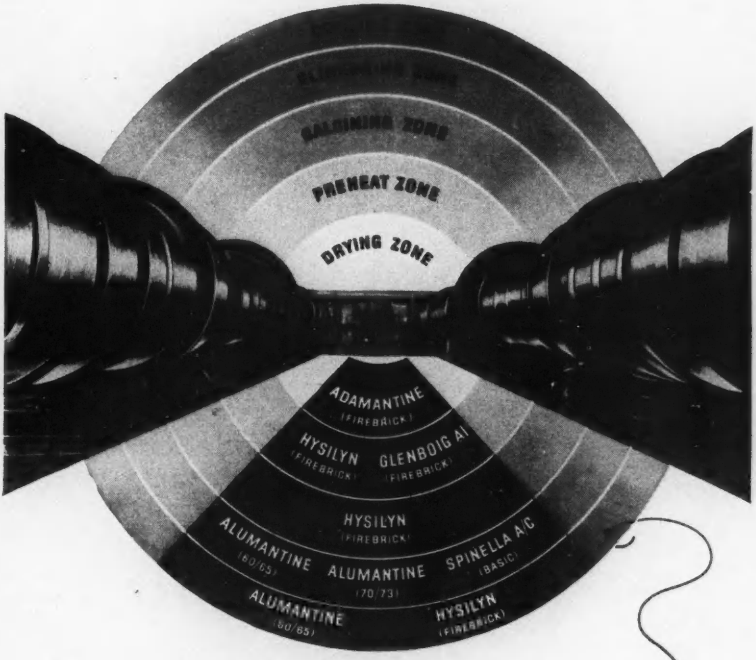

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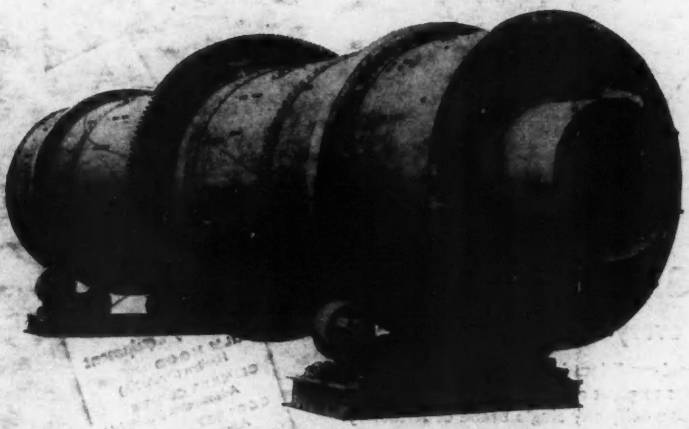

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